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EXTENDING THE GRAZING SEASON THROUGH THE USE OF SEEDED SPRING AND WINTER TRITICALE OR PERENNIAL RYE CEREALS FOR PASTURES

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Extending the grazing season through the use of spring and winter seeded triticales or perennial rye cereals for pastures

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Abstract

Perennial cereal (PC) rye has been developed as a new forage crop with high yield and quality for the beef industry of western Canada. However, winter hardiness and stand persistence of PC rye under different grazing and forage harvesting needs to be evaluated for the semiarid prairie area. Objectives were to evaluate the feasibility of using PC rye and spring-planted spring and winter triticale intercrop as a way to improve pasture yields, distribution, animal performance and to extend the grazing season compared to Russian wildrye, and to evaluate the influence that agronomic practices, such as grazing and haying, have on forage production, persistence and economic returns. Results found that PC rye's ability to establish on dry land conditions and survive over winter in the southwest Saskatchewan is very dependent upon seeding date. Planting PC rye in mid-August or later may ensure maximum winter hardiness, while planting in mid-July may significantly lower winter hardiness. Study conclusions found that agronomic and economic results do not provide strong support for the use of PC rye as an alternative pasture source in place of annual cereal or perennial grass production systems in southwestern Saskatchewan under the conditions experienced over the 2001-2004 time period.

Executive Summary

Spring cereals can provide excellent early spring grazing. However, the rapid change from vegetative to floral tillers limits their use and specific grazing management is required to maximize pasture production. Seeding a winter cereal in the spring is a relatively new practice that can provide excellent quality late season pasture because the crop will not head out. Fall rye, winter wheat and winter triticale have all been successfully used for this purpose in southwest Saskatchewan (Springer 1999). Baron et al. (1993) concluded that intercropping spring and winter cereals were a feasible system and that it was the best alternative where annual forage was required for full-season pasture. Recently, a perennial cereal (PC) rye has been developed as a new silage crop with high yield and quality for the beef industry of western Canada. PC rye could help reduce soil erosion and contribute to improved soil structure and organic matter content, while reducing seeding costs compared to annual cereal and providing a new feed for ruminants (Acharya 1998; Zamam et al. 1999). One of PC rye key feature is its longevity of over three to four growing seasons (Meristem Information Resources Ltd. 2004). However, the winter hardiness and stand persistence of PC rye under different grazing and forage harvesting needs to be evaluated and research is lacking for the semiarid prairie area.

Objectives of this study were to evaluate the feasibility of using PC rye and spring-planted spring and winter triticale intercrop as a way to improve pasture yields, distribution, animal performance and to extend the grazing season compared to Russian wildrye, and to evaluate the influence that agronomic practices, such as grazing and haying, have on forage production, persistence and economic returns.

The study was conducted at the Semiarid Prairie Agricultural Research Centre (SPARC) near Swift Current, Saskatchewan on six pastures. Each pasture was four acres (1.62 ha) in size. The soil type of the pastures was Swinton loam (Ayres et al. 1985). The mean (118 yr) annual precipitation is 360 mm and the mean growing season precipitation (April-August) is 233 mm. Three forage treatments (PC rye, spring and winter triticale (S+W triticale) and Russian wildrye (RWR)) were applied to the pastures and two type of forage harvesting schedules (grazing +

grazing or haying + grazing) were followed if sufficient moisture for regrowth occurred.

Although PC rye has been reported to stay in production between three to four years in dry land conditions, this was not observed at the AAFC-SPARC location. Due to a number of possible reasons (unique environmental condition, poor winter survivability, grazing stress etc.) the PC rye did not survive three out of the four winters that it was evaluated under large pasture conditions. In June of 2000 the PC rye was seeded into pastures one and two using 9 in (23 cm) row spacing by a hoe drill. The PC rye seed was supplied from the Lethbridge Research Centre – AAFC and the PC seeding rate was 100 lb ac^{-1} (112 kg ha^{-1}). Fertilizer was applied at the rate of 50 lb ac^{-1} (56 kg ha^{-1}) of mono-ammonium phosphate (11-51-00). In 2001 (July) and 2002 (August) the PC rye was re-seeded using the same row spacing, seeding and fertilizer rate, but seeding was done using a Flexicoil air seeder. PC rye plant counts per m^2 were taken each year in the fall at 10 random sites within the field. In 2001, spring (cv. Pronghorn) and winter (cv. Bobcat) triticales were seeded as an intercrop on May, in pastures three and four. The seeding rate was 130 lb ac^{-1} (146 kg ha^{-1}) of a 50:50 mixture of the two triticales. Fertilizer was applied at a rate of 50 lb ac^{-1} (56 kg ha^{-1}) of 11-51-00. The triticale pastures were seeded using a 9 in (23 cm) row spacing by a hoe drill. In 2002, 2003 and 2004 the S+W triticales were seeded using the same row spacing and fertilizer rate, but seeding rate was 90 lb ac^{-1} (101 kg ha^{-1}) and seeding was done using a Flexicoil air seeder. Pastures five and six were existing RWR pastures that had been previously established in 1993. Although the RWR pastures were not re-seeded, all of the cereal and grass forage treatments (i.e., PC rye, S+W triticale and RWR) were balanced each spring for their nitrogen soil fertility to maintain it at about100 lb of actual N ac^{-1}.

Due to the drought of 2001 and high nitrate-N levels in the forage no grazing treatments were conducted and all pastures (PC rye, S+W triticale and RWR) were cut for hay production and discarded. In 2002, due to potential drought concerns, cow/calf pairs were used for the spring grazing and yearling Red Angus steers were used for the late summer/fall grazing. In 2003 yearling Hereford steers were used for the grazing period while in 2004 yearling Red Angus steers were used. Prior to the cattle entering and coming off each pasture, they were weighed. A pencil shrink of 5% was used for the cows and calves and an 8% for the heavy steers which previous studies have shown is close to the average shrink obtained after an overnight fast from feed and water. Stocking rates in 2002, 2003 and 2004 in the fall and spring grazing periods ranged from 2.6 to 5.2 AU per ac^{-1}, 3.0 to 5.2 AU per ac^{-1} and 3.2 AU per ac^{-1}, respectively. Grazing utilization for each pasture was targeted at 50 to 55% and was visually estimated. The S and W triticale pastures were grazed at the boot/heading and tillering stages, respectively. The PC rye and RWR pastures were grazed at the tillering/boot and boot/heading stages, respectively. Pastures that were hayed were harvested using a12 ft Haybine and round baled. The S and W triticale pastures were cut for hay at the soft dough and tillering stages, respectively. The PC rye and RWR pastures were hayed at the flowering and heading stages, respectively.

Because the PC rye on the large pasture study failed to successfully establish a small plot study was initiated to evaluate PC rye's winter-hardiness and the effect of defoliation on plant survival. Plots were seeded on the following six seeding dates in 2001: July 18, August 3, August 16, August 30, September 7 and September 17. All plots were seeded at the rate of 700 pure live seeds. The seed was placed at a depth of 1.25 cm using a plot-seeder with 25 cm row spacing. Five winter cereal varieties, from three species, were seeded in this project for comparison to PC rye. Prima fall rye, CDC Clair winter wheat, Pika winter triticale and Bobcat winter triticale were chosen because they are traditionally grown on the western prairies. Prego winter triticale, a high-yielding variety from Europe, was selected to see how this European

variety differs in winter hardiness from the Canadian varieties.

Results from the large pasture study from 2000, 2001 and 2004 showed that winter hardiness and stand persistence of PC rye is a concern, especially if this crop is to be grown in southwest Saskatchewan. Planting PC rye in mid-August or later may ensure maximum winter hardiness. In 2000 and 2001, when the PC rye was seeded in the large pastures before August the stands did not survive over winter. In agreement, results from the small plot study reported that the optimum time to plant PC rye to ensure maximum winter hardiness was mid-to-late August, while planting in mid-July would significantly lower hardiness. In 2003, with good spring moisture, PC rye available forage yields during grazing (5,083 lb ac^{-1} or 5,696 kg ha^{-1}) and haying (4,722 lb ac^{-1} or 5,292 kg ha^{-1}) were higher than either RWR or S+W triticales at grazing or haying. It is unclear whether the poor winter survival of PC rye was due to low winter hardiness or weather extremes. Although the PC rye provided excellent forage biomass and quality and grazing performance (2.5 lb d^{-1} or 1.2 kg ha^{-1}) in 2003 (first production year) the forage performance of PC rye does decline over years. It has been reported that in a two cropping system that PC rye forage production declines by 20% within the first three years, with a further 30% decline during the fourth year (S. Acharya personal communication 2005). Continual research is needed to evaluate PC rye's longevity under forage and grazing production and its ability to survive winter conditions in southwest Saskatchewan.

Use of S+W triticales can provide an important grazing and forage resource, especially if good moisture is received to meet the growing needs of the seedling. In 2004, the highest available forage yield occurred for S+W triticale harvested for hay with a value of 5,774 lb ac^{-1} (6,472 kg ha^{-1}). However, in 2003, even with good spring moisture the very hot and dry conditions observed at the end of June and all of July adversely affected the S+W triticale forage productions much more than for the perennial forages. The rooting system of annual cereals are quite shallow, while perennial forages have much more extensive rooting system which enable them to better tolerate moisture deficiencies. Results from this study showed that grazing management of annual cereals such as S+W triticales are extremely important in order to achieve any animal gains. When using S triticale it is important that grazing occurs before the boot stage of maturity; if this is not possible then it maybe better to hay the material than to attempt grazing since palatability concerns become an issue. If proper grazing management is used to graze S+W triticale (boot stage) excellent cattle gains (2.8 lb d^{-1} or 1.3 kg d^{-1}) and total live productions (110 lb ac^{-1} or 124 kg ha^{-1}) can be achieved as were observed in 2004.

Results from the 2003 showed the benefit that perennial forages, such as RWR and PC rye have in forage production over a traditional cereal crop seeded in the spring. The early spring moisture was utilized by the perennial forages giving good forage production while later seeded annual cereals produced less forage biomass when subjected to dry and hot summer conditions. When comparing the average available hay and grazing forage yields over three years of production (2002 to 2004) for S+W triticale and RWR there were no significant differences ($P>0.30$). The S+W triticales consistently gave higher average forage biomass yields over RWR by as much as 11% for grazing and 25% for haying. However, the added cost and labour of re-seeding the annual cereal crop each year for the potential forage increase may not have much economical benefit. Average total live weight grazing production for RWR over the three years was numerically ($P=0.08$) higher than S+W triticale and the values were 182 lb ac^{-1} (204 kg ha^{-1}) vs. 99 lb ac^{-1} (111 kg ha^{-1}), respectively. Average grazing days per acre did not differ ($P>0.30$) between RWR and S+W triticale over the three years and the values were 58 d ac^{-1} (146 d ha^{-1}) vs. 44 d ac^{-1} (109 d ha^{-1}), respectively. Over the three years of the study the RWR grazing

pasture total available biomass production ranged from 1,024 lb ac^{-1} (1,432 kg ha^{-1}) to 3,388 lb ac^{-1} (3,798 kg ha^{-1}). The higher than expected forage production is attributed to those years that had good spring and summer precipitation and the supply of N fertilizer each year. Holt (1996) reported that long term RWR forage yields with no fertilization ranged from 540 to 600 lb ac^{-1}, but with the inclusion of a legume, a forage yield of 1,480 lb ac^{-1} was observed. Although the RWR pastures had very good forage production for pastures over 10 years old, the main complaint about RWR is its lack of productivity in the long term due to its high demand for soil nitrogen. In the case of this study's RWR pastures, the addition of nitrogen fertilization or other renovation techniques will be needed if the forage production goal is to maintain 1,000 lb ac^{-1} which is an important cost consideration.

Conclusions from this study have shown that the ability for PC rye to establish on dryland conditions and survive over winter in the southwest is questionable and very much dependent upon its seeding date. The small plot study found that planting PC rye in mid-August or later may ensure maximum winter hardiness, while planting in mid-July may significantly lower winter hardiness. When seeded in August, PC rye's plant survival rate was equal to fall rye which is noted for its winter hardiness. In agreement, the large pasture study was only successful in establishing the PC rye and surviving the winter when it was seeded in August of 2002. Previous seeding dates in June (2000) and July (2001) resulted in none of the PC rye plants surviving the winter. Why the PC rye from 2003 did not survive through to 2004 maybe due to the drought conditions experienced in the summer of 2003 or a combination of the drought and grazing stress. In support, the small plot study also observed that PC rye's plant survival can be significantly reduced when PC rye is seeded in July and defoliated in the fall. PC rye can provide excellent forage biomass for haying and grazing and its forage quality can result in good animal performances. However, the key to PC rye's success is very much dependent upon its ability to stay in production for three to four years which may not be the case in southwest Saskatchewan.

For the study, both S+W triticales and RWR pastures generally produced good forage biomass and forage quality that resulted in good animal performance. However, the results of 2002 and 2004 showed that grazing management of annual cereals such as S+W triticale is extremely important in order to achieve desired animal gains. When using S triticale it is important that grazing occurs before or at the boot stage of maturity; if this is not possible then it may be better to hay the material than to attempt grazing since palatability concerns may be an issue. Another major draw back to the use of spring seeded annuals for forage production in southwest Saskatchewan is potential moisture limitations. Unlike perennial forages that can utilize early spring moisture to get some production, the spring seeded annual is much more sensitive to moisture deficiencies and poorer production as a result of limited spring and summer moisture conditions. Moreover, the added cost each year of re-seeding makes this type of forage operation more costly. Although the establishment of a perennial forage can also be costly, this cost can be amortized over a number of years. In the case of RWR, more than ten years of modest forage production (500 to 600 lb ac^{-1}) can occur or with fertilization and favourable environments higher forage production can be achieved. The potential increase in forage production, grazing capacity, improved forage quality and reduced production variability may have additional monetary value to the producer's operation to offset the cost of the fertilizer and application.

Although the results of the economic analysis is considered preliminary, the overall general ranking of the pasture systems was RWR-grazed > triticale-grazed = PC rye-hayed/grazed > RWR-hayed/grazed > triticale-hayed/grazed = PC rye-grazed. Thus, the evidence does not

provide strong support for the use of PC rye as an alternative pasture source to annual cereal or perennial grass production systems in southwestern Saskatchewan under the conditions experienced over the 2001-2004 time period. With the inability of PC rye to consistently provide three to four years of production and the uncertainty on its ability to handle grazing stresses, there is the need for further evaluation and research before this forage crop can be recommended for use in southwest Saskatchewan in place of other forage sources.

Introduction

The principles and concepts of grazing annuals in the semiarid prairie area are not new (Lodge 1971; Kilcher and Lawrence 1979), however, the introduction of new annual and perennial cereal varieties and species warrants further evaluation. Especially since cattle numbers in Canada have increased in the last two years and there is increasing need for more grazing and forage resources. Spring cereals can provide excellent early spring grazing. However, the rapid change from vegetative to floral tillers limits their use and specific grazing management is required to maximize pasture production. Seeding a winter cereal in the spring is a relatively new practice that can provide excellent quality late season pasture because the crop will not head out. Fall rye, winter wheat and winter triticale have all been successfully used for this purpose in southwest Saskatchewan (Springer 1999). Baron et al. (1993) concluded that intercropping spring and winter cereals were a feasible system and that it was the best alternative where annual forage was required for full-season pasture. Another forage cereal, perennial cereal (PC) rye has been developed at the Lethbridge Research Centre as a new silage crop with high yield and quality for the beef industry of western Canada. PC rye could help reduce soil erosion and contribute to improved soil structure and organic matter content, while reducing seeding costs compared to annual cereal and providing a new feed for ruminants (Acharya 1998; Zamam et al. 1999). Recently, seed for the first PC rye variety, ACE-1 is now available from Kenneth Long Seeds Inc. in southern Alberta. One of PC rye's key features is its longevity of over three to four growing seasons (Meristem Information Resources Ltd. 2004). However, the winter hardiness and stand persistence of PC rye under different grazing and forage harvesting needs to be evaluated and research is lacking for the semiarid prairie area.

Project Objectives:

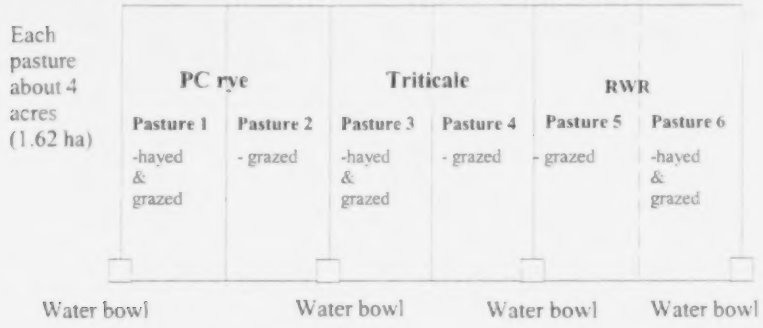
1. To evaluate the feasibility of using PC rye and spring-planted spring and winter triticale intercrop as a way to improve pasture yields, distribution, animal performance and to extend the grazing season compared to Russian wildrye;
2. To evaluate the influence that agronomic practices, such as grazing and haying, have on forage production, persistence and economic returns.

Materials and Methods

Project Design

The study was conducted at the Agriculture and Agri-Food Canada - Semiarid Prairie Agricultural Research Centre (AAFC-SPARC) near Swift Current, Saskatchewan on six pastures (Fig. 1). Each pasture was four acres (1.62 ha) in size. The soil type of the pastures was Swinton loam (Ayres et al. 1985). The mean (118 yr) annual precipitation is 360 mm and the mean growing season precipitation (April-August) is 233 mm. Three forage treatments (PC rye, spring and winter triticale (S+W triticale) and Russian wildrye (RWR)) were applied to the pastures and two type of forage harvesting schedules (grazing + grazing or haying + grazing) were followed if sufficient moisture for regrowth occurred.

Figure 1. Grazing pastures for perennial and annual cereals



Large pasture study (spring and winter triticale, perennial cereal rye and Russian wildrye)

2000

Perennial cereal rye seed was supplied from the Lethbridge Research Centre with AAFC. The PC rye was seeded in pastures one and two using a 9 in (23 cm) row spacing by a hoe drill on June 28. Seeding rate was 100 lb ac^{-1} (112 kg ha^{-1}). Fertilizer was applied at the rate of 50 lb ac^{-1} (56 kg ha^{-1}) of mono-ammonium phosphate (11-51-00). The PC rye establishment was excellent and estimated forage yield at the flag leaf stage harvested in September was 2,400 lb ac^{-1} (2,688 kg ha^{-1}). Sixty five cow/calf pairs were allowed to graze the PC rye field for four days to about 50% utilization. Plant counts on the PC rye were taken on October 25 at 10 random sites within the entire PC rye field. The average plant population was 158 plants m^2. Unfortunately, the established PC rye stand did not survive the winter of 2000/2001.

2001

In 2001 the PC rye was re-seeded using a 9 in (23 cm) row spacing on July 18, with a Flexicoil air seeder. Prior to seeding, the field was sprayed with the herbicide Roundup to kill any annual and perennial weeds. The seed and fertilizer rates were the same as in the previous year. The drought of 2001 greatly affected the PC rye stand establishment. Plant counts on the re-seeded PC rye were taken on September 28 at 10 random sites within the field and the average plant population was 67 plants per m^2. Unfortunately, for a second time, the PC rye stand did not survive the winter 2001/2002.

Adjacent to the PC rye field, spring (cv. Pronghorn) and winter (cv. Bobcat) triticales were seeded as an intercrop on May 1, in pastures three and four. The seeding rate was 130 lb ac^{-1} (146 kg ha^{-1}) of a 50:50 mixture of the two triticales. A higher than expected seeding rate occurred due to technical problems with the seeder. Fertilizer was applied at a rate of 50 lb ac^{-1} (56 kg ha^{-1}) of 11-51-00. The triticale pastures were seeded using a 9 in (23 cm) row spacing by a hoe drill. Excellent establishment of the S+W triticales was observed, however, the drought conditions of 2001 greatly affected the later growth of the stand.

Pastures five and six were existing RWR pastures that had been previously established in 1993 and were four acres (1.62 ha) each in size.

2002

The PC rye was re-seeded with the same air seeder and seeding procedure as in 2001, except seeding occurred on August 22. Prior to seeding the field was sprayed with the herbicide Roundup to kill any annual and perennial weeds. Good germination of the PC rye was observed, but extensive grasshopper damage occurred on the PC rye seedlings, especially the areas bordering the native pasture areas. Although the PC rye field was sprayed on September 16 with

the insecticide Decis at 0.013 gallons ac^{-1} (0.15 L ha^{-1}), considerable grasshopper damage still occurred. Plant counts on the re-seeded PC rye were taken on October 15 at 10 random sites within the field and the average plant count was 86 plants per m^2.

Similar to 2001, S+W triticales were seeded as an intercrop on May 17. Seeding rate was a 50:50 mixture for the two triticales at about 90 lb ac^{-1} (101 kg ha^{-1}) and fertilization rate and row spacing were the same as in 2001. The triticale pastures were seeded using a Flexicoil air seeder. The triticale fields were sprayed on June 7, with a 2- 4D Amine 600 herbicide (@ 0.88 L ha^{-1}).

The RWR pasture was split in half (pasture five and six) with each pasture about four acres in size (1.62 ha). On May 1, about 200 lb ac^{-1} (224 kg ha^{-1}) of 46-00-00 fertilizer was applied to the RWR pastures. Nitrogen (N) soil fertility was balanced across all cereal and grass treatments (i.e., PC rye, S+W triticale and RWR) at about 100 lb of actual N ac^{-1}. Because the RWR pastures were in production the longest and received no previous N fertilization, these pastures had the highest N fertilizer requirements.

2003

The PC rye survived the winter of 2002/2003 and plant counts on the pasture were taken on April 23 at 10 random sites. The average plant count was about 89 plants per m^2 which was similar to the average plant count observed in the fall of 2002. Unfortunately, for a third time, the PC rye stand did not survive the winter of 2003/2004.

Similar to 2001 and 2002, S+W triticales were seeded as an intercrop on May 19. Seeding equipment and rate for the two triticales were the same as in 2001 and 2002. Fertilization rate was 50 lb ac^{-1} (56 kg ha^{-1}) of 11-51-00 and an additional 170 lb ac^{-1} (190 kg ha^{-1}) of 46-00-00 fertilizer was applied to balance N soil fertility across all cereal and grass treatments. The triticale fields were sprayed on May 15, with Vantage Plus (@ 1 L ac^{-1}).

On May 8, about 200 lb ac^{-1} (224 kg ha^{-1}) of 46-00-00 fertilizer was applied to the RWR pastures in order to balance N soil fertility across all cereal and forage treatments.

2004

Once again PC rye did not survive the winter of 2003/2004 and was re-seeded on August 30. The drought and high temperatures in July and August of 2003 greatly affected the PC rye stand. Plant counts on the PC rye were taken on October 7 at 10 random sites within the two pastures and the average plant count was 72 plants per m^2.

Similar to 2001, 2002 and 2003, S+W triticales were seeded as an intercrop on April 2. Seeding equipment and rate were similar as in the previous three years for the two triticales. This year the only fertilizer that was applied was 50 lb ac^{-1} (56 kg ha^{-1}) of 11-51-00 fertilizer. Last year's poor summer growing conditions resulted in little of the N soil profile (top two ft) being utilized. The triticale fields were sprayed on May 27, with 2-4D (@ 1 L ac^{-1}).

On May 4, about 200 lb ac^{-1} (224 kg ha^{-1}) of 46-00-00 fertilizer was applied to the RWR pastures to maintain N soil fertility balance across all cereal and grass treatments.

Grazing and forage production

Due to the drought of 2001 and high nitrate-N levels in the forage no grazing treatments were conducted and all pastures (PC rye, S+W triticale and RWR) were cut for hay production (Table 1). The spring of 2002 also appeared to be a repeat of 2001, thus a decision was made to reduce the SPARC cattle herd. The reduction in beef cattle numbers required that cow/calf pairs were

used for the spring grazing and yearling Red Angus steers were used for the late summer fall grazing. In the spring of 2003 yearling Hereford steers were used and in 2004 yearling Red Angus steers were used for the grazing period. Prior to the cattle entering and coming off each pasture, they were weighted. Since the shrinking of calves prior to each weighing during a trial period has an adverse effect on gains, animals were not fasted overnight prior to weighing. Therefore, a pencil shrink of 5% was used for the cows and calves, and an 8% shrink for the heavy steers. Data collected at AAFC-SPARC has shown that a 5 to 8% shrink is the average shrink obtained after an overnight fast (12 hrs) from feed and water. Stocking rates and types of cattle used during the grazing treatment are listed in Table 1. Grazing utilization for each pasture was targeted at 50 to 55% and was visually estimated. It is acknowledged that livestock usually lose weight when moved from dry feed to fresh herbage (Clark and Campbell 1969). Therefore various management practices such as placing animals on a pretest or holding pasture containing good old or new growth prior to the animals going onto the test pastures were applied to reduce the drop in weight and shorten the recovery period.

The RWR, PC rye and triticale pastures were swathed down using a 12 ft Hesston and round baled. The triticales in pasture three were normally cut for hay in July in 2003 and 2004, while in 2002 the triticales were harvested for hay in August due to cool temperatures and abundant moisture received that year (Table 1). All of the S-W triticales were harvested for hay at the soft dough and tillering stage, respectively. The RWR pasture number six was cut for hay at the heading stage in 2002, 2003 and 2004 (Table 1). Only in 2003 was PC rye pasture number 1 cut for hay in June at the flowering stage (Table 1). In all years except 2001 and 2003, the moisture and environmental conditions were good enough to support some plant regrowth after initial forage harvesting (grazing or haying). All forage bales were hauled off the field and weighed to determine total forage production per pasture.

Table 1. Grazing and hay harvesting dates, cattle type and animal numbers that were used in the cereal and grass grazing study each year from 2001 to 2004

Year and treatments	Date grazing commenced or hayed	Cattle type	Cattle #
2001	no growth due to drought		
2002 (June and July with abundant moisture)			
PC rye (pastures 1 and 2)	no grazing occurred due to winter kill		
Spring and winter triticale (pasture 3)	August 15 (cut for hay)		
Spring and winter triticale (pasture 3)	September 16	steer	12
Spring and winter triticale (pasture 4)	July 12	cows & calves	27
Spring and winter triticale (pasture 4)	September 16	steer	12
RWR (pasture 5)	July 12	cows & calves	27
RWR (pasture 5)	September 24	steer	12

used for the spring grazing and yearling Red Angus steers were used for the late summer/fall grazing. In the spring of 2003 yearling Hereford steers were used and in 2004 yearling Red Angus steers were used for the grazing period. Prior to the cattle entering and coming off each pasture, they were weighed. Since the shrinking of calves prior to each weighing during a trial period has an adverse effect on gains, animals were not fasted overnight prior to weighing. Therefore, a pencil shrink of 5% was used for the cows and calves, and an 8% shrink for the heavy steers. Data collected at AAFC-SPARC has shown that a 5 to 8% shrink is the average shrink obtained after an overnight fast (12 hrs) from feed and water. Stocking rates and types of cattle used during the grazing treatment are listed in Table 1. Grazing utilization for each pasture was targeted at 50 to 55% and was visually estimated. It is acknowledged that livestock usually lose weight when moved from dry feed to fresh herbage (Clark and Campbell 1969). Therefore various management practices such as placing animals on a pretest or holding pasture containing good old or new growth prior to the animals going onto the test pastures were applied to reduce the drop in weight and shorten the recovery period.

The RWR, PC rye and triticale pastures were swathed down using a 12 ft Haybine and round baled. The triticales in pasture three were normally cut for hay in July in 2003 and 2004, while in 2002 the triticales were harvested for hay in August due to cool temperatures and abundant moisture received that year (Table 1). All of the S+W triticales were harvested for hay at the soft dough and tillering stage, respectively. The RWR pasture number six was cut for hay at the heading stage in 2002, 2003 and 2004 (Table 1). Only in 2003 was PC rye pasture number 1 cut for hay in June at the flowering stage (Table 1). In all years except 2001 and 2003, the moisture and environmental conditions were good enough to support some plant regrowth after initial forage harvesting (grazing or haying). All forage bales were hauled off the field and weighed to determine total forage production per pasture.

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2001	no growth due to drought		
2002 (June and July with abundant moisture)			
PC rye (pastures 1 and 2)	no grazing occurred due to winter kill		
Spring and winter triticale (pasture 3)	August 13 (cut for hay)		
Spring and winter triticale (pasture 3)	September 16	steers	15
Spring and winter triticale (pasture 4)	July 12	cows & calves	21
Spring and winter triticale (pasture 4)	September 16	steers	15
RWR (pasture 5)	July 12	cows & calves	21
RWR (pasture 5)	September 24	steers	15

RWR (pasture 6)	July 22 (cut for hay)		
RWR (pasture 6)	September 24	steers	15
2003 (July and August very hot and dry)			
PC rye pasture 1	June 12 (cut for hay)		
PC rye pasture 1	July 22	steers	17
PC rye pasture 2	May 28	steers	17-30[1]
PC rye pasture 2	July 22	steers	17
Spring and winter triticale (pasture 3)	July 24 (cut for hay)		
Spring and winter triticale (pasture 4)	July 12	steers	17
RWR (pasture 5)	May 28	steers	15
RWR (pasture 6)	June 12 (cut for hay)		
2004			
PC rye (pastures 1 and 2)	no grazing occurred due to winter kill		
Spring and winter triticale (pasture 3)	July 28 (cut for hay)		
Spring and winter triticale (pasture 3)	Sept 01	steers	18
Spring and winter triticale (pasture 4)	June 25	steers	18
Spring and winter triticale (pasture 4)	Sept 01	steers	18
RWR (pasture 5)	June 11	steers	19
RWR (pasture 5)	Sept 01	steers	18
RWR (pasture 6)	June 23 (cut for hay)		
RWR (pasture 6)	Sept 01	steers	18

[1]Initially, 17 yearling steers were put on the pasture for 6 days then an additional 13 steers were place on the pasture for another 13 days.

Forage quality analyses

For each pasture treatment, five random forage samples were taken at different stages of maturities (i.e., vegetative, tillering, heading, soft dough etc.) that corresponded to when the pastures and hay field were harvested. Forage samples were dried in a forced-air oven at 60^0C after arrival at SPARC. Samples were ground in a Wiley mill to pass through a 1-mm screen, labelled, and placed in glass jars. *In vitro* organic matter digestibility (IVOMD), crude protein

(CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) and certain minerals (N,P, K, Mg & S) were determined for each sample using Standard Operating Procedures Forage Laboratory (2001). Nitrate-N levels were also determined (Hamm et al. 1970) during those years in which nitrate-N levels in triticale and PC rye pastures could increase within forage or grazing material during drought or limited moisture times.

Soil fertility

Soils samples (core 3.8 cm diam.) were taken at 15-cm increments to a 60-cm depth in the spring (April) of 2001, 2002 and 2003. We used the fall soil samples from each year to determine soil nitrogen (N) requirements for the following spring and all cereal and grass treatments were balanced for N at about 100 lbs per acre. Five sites per pasture were soil sampled and sub-samples were processed separately and analysed for soil moisture, N, phosphorus (P) and sulfur (S) according to Methods Manual Scientific Support Section Analytical Chemistry Laboratory (1998).

Small plot study

2001

Due to the winter kill problems associated with the PC rye seeded in 2000, an additional small plot study was initiated to evaluate PC rye's winter-hardiness and the effect of defoliation on plant survival. The research site was a randomized split-split-plot, with four replications in each seeding date. Whole plots were the six seeding dates, with variety as sub-plots and defoliations (mowed vs. un-mowed) as sub-sub-plots. On July 18, the site was worked with a cultivator and harrow-packed to create a firm seedbed. Plots were seeded on the following six seeding dates in 2001: July 18, August 3, August 16, August 30, September 7 and September 17. All plots were seeded at the rate of 700 pure live seeds. The seed was placed at a depth of 1.25 cm using a plot seeder with 25 cm row spacing. Although no soil test was done to determine soil nutrient status, 50 lb ac^{-1} (56 kg ha^{-1}) of 11-51-0-0 fertilizer was applied with the seed.

Five winter cereal varieties, from three species, were seeded in this project for comparison to PC rye. Prima fall rye, CDC Clair winter wheat, Pika winter triticale and Bobcat winter triticale were chosen because they are traditionally grown on the western prairies. Prego winter triticale, a high-yielding variety from Europe, was selected to see how this European variety differs in winter hardiness from the Canadian varieties.

Since 2001 was a drought year, irrigation was applied twice during the establishment year of the study in order to ensure sufficient moisture for germination at each of the seeding dates. The research site was irrigated on August 13 and September 11, with approximately 5 cm of moisture applied each time.

A defoliation (mowing) treatment occurred during the first week of October, defoliating the plants to a height of 5 cm. This defoliation date was selected because fall grazing of winter cereals often occurs at this time due to depletion of perennial pastures.

2002

On May 10 and 11, field survival and mortality counts were done for each plot. Within each plot, 50 randomly selected plants were evaluated to determine percent survival and mortality under field conditions at Swift Current. Any plant with green growth as of the date of sampling was considered alive.

Economic Analyses

The net margins for the six grazing and hay/grazing pasture systems were determined annually using a partial budgeting framework (Doll and Orazem 1978). Only costs that differed among the treatments were considered, i.e., costs for seed, planting, herbicides used for weed control, fertilizers, hay harvest (where applicable), and maintenance of the animals while on pasture. The experimental data were extrapolated to the 'farm-level' using a representative farm size of 1275 ha. In the case of PC rye, the initial cost of establishing the pastures (seed, fertilizer, herbicides, and machine operations) was spread over a 4-year period ($35.57 ha^{-1} yr^{-1}), under the assumption that PC rye pastures were estimated to persist for 3 to 4 years in this region under normal conditions (Meristem Information Resources Ltd. 2004). For RWR, the annualized cost of establishing the pastures ($4.36 ha^{-1} yr^{-1}) was estimated and amortized over a 15 year period, while the annual cost of establishing the triticale intercrop pastures over the study period averaged $78.11 ha^{-1}. The quantity of forage harvested as hay was estimated as 65% of the total above-ground biomass production, based on hand samples taken generally at flowering for PC rye, soft dough for spring triticale and tillering for winter triticale, and at heading for RWR. The cost of inputs and field operations used in the analysis reflect 2004 conditions (Saskatchewan Agriculture, Food and Rural Revitalization 2004; University of Saskatchewan 2004) (Table 2). The economic performance of each treatment was evaluated for high and low prices for steers ($2.20 and $1.98 kg^{-1}, respectively), calves ($3.31 and $2.43 kg^{-1}), and hay ($80 and $50 t^{-1}) to test the sensitivity of the findings to changes in these price conditions. Data for 2001, and data for the PC rye treatments in 2002 and 2004, were excluded from the analysis.

Because the economic performance of the PC rye pastures could only be determined for the 2003 experimental year, a simulated 4-year scenario was defined for these pasture systems and then compared to the mean performance of the triticale and RWR pasture treatments. For this purpose, we assumed that the 2003 data were reflective of the average year-one production levels (i.e., incremental quantities of beef and hay produced) that could be obtained with the PC rye pasture systems, and that future productivity declined by 20% by the end of year-three, and it declined a further 30% by the end of year-four. Thus the assumed productivity indices for the PC rye pastures were 100% of the 2003 beef and hay production levels in year-one, 90% in year-two, 80% in year-three, and 50% in year-four. The annual net margin values for the simulated PC rye pastures were then meaned over the four years and compared to the 2002-2004 mean performance of the other pasture systems so as to get a better sense of their relative economic performance.

All economic results are expressed on a per hectare basis.

Table 2. Summary of economic parameters.

Input Item	Cost	Units
Seed		
PC Rye	0.39	$ kg^{-1}
Triticale	0.19	$ kg^{-1}
Russian wildrye[1]	4.36	$ ha^{-1}
Fertilizer		
46-0-0	0.36	$ kg^{-1}
11-51-0	0.37	$ kg^{-1}

Herbicides		
Glyphosate	8.99	$ L^{-1}
2,4-D amine	6.96	$ L^{-1}
Labor	9.00	$ hr^{-1}
Animal care[2]	0.40	$ day^{-1}
Machine Operations[3]		
Zero-till hoe drill	25.57	$ ha^{-1}
Spray	7.76	$ ha^{-1}
Fertilizer broadcast	6.18	$ ha^{-1}
Transport - seed & fertilizer	9.13	$ ha^{-1}
Mower conditioner	28.22	$ ha^{-1}
Round baling	9.02	$ t^{-1}
Bale hauling	4.54	$ t^{-1}

[1] Reflects the amortized cost of seed and seeding the RWR pastures over a 15 year period.
[2] Reflects the combined costs for veterinary supplies, salt, watering, fence repair and labor for the care and maintenance of animals while on pasture.
[3] Includes fuel, oil, repairs and fixed machine costs, plus labor.

Statistical Analyses

The large pasture study was initially setup as a completely randomized design with year as a random factor and treatments as a fixed factor. Where possible and using years as replicates the data were analyzed using the Proc Mixed procedure of SAS (SAS Institute 1990). Lsmeans were separated by PDiff with significance considered at $P<0.05$, unless otherwise stated. However, the loss of the PC rye treatment due to winter kill in two out of the four years of the study and another year of data lost due to the drought of 2001 greatly affected the ability to run a meaningful statistical analysis on the remaining data. Much of the data is presented by year since each year had large difference in environmental conditions.

For the small plot study the data was analysed using Proc Mixed (SAS Institute 1990). A split-split model was used with seeding date, species, defoliation and their interactions as fixed effects and replicates as random effects. Significant seeding date X species X defoliation interactions for plant survival and plant height were further examined by removing seeding date from the model, and analyzing the experimental data within each seeding date separately. Lsmeans comparisons generally emphasized comparisons among forage varieties and defoliation treatments within seeding dates, rather than direct comparisons among seeding dates. Significance was considered at $P<0.05$, unless otherwise stated.

Results and Discussion

2001 and 2002

Forage and grazing performance

Unfortunately, once again the PC rye pastures established in 2001 did not survive the winter (Appendix Fig. 1). The drought of 2001 severely limited the ability of the PC rye to grow and build-up root reserves to survive the winter of 2001/2002. Also the winter and spring period of

2002 observed little snowfall for insulation and the lower than normal temperatures for the month of March probably contributed to the poor plant survival. It is unclear whether the poor winter survival of PC rye was due to low winter hardiness or weather extremes. For this reason a small plot study was initiated to evaluate PC rye's winter hardiness. Plant count comparisons between the PC rye established in 2000 vs. later years were much lower. In 2000, the plant count was 158 plants per m^2, versus 67 and 86 plants per m^2 in 2001 and 2002, respectively. Plant seedling numbers in 2002 were higher than 2001, but the plant count values were less than half of the 2000 plant count. The 2001 drought, greatly affected the cereal and grass treatments and little forage growth and production occurred, therefore no data was collected for that year.

The good moisture received in 2002 resulted in better forage yields for the RWR and S+W triticale pastures (Table 3). Available forage yields (DM basis) for RWR and S+W triticale pastures harvested at a growth stage best for haying were 2,500 and 3,990 lb ac^{-1} (2,800 and 4,500 kg ha^{-1}), respectively. Available forage yields for RWR and S+W triticale pastures harvested at a growth stage best for grazing were about 1,922 and 2,095 lb ac^{-1} (2,154 and 2,348 kg ha^{-1}), respectively. The lower forage yields associated with grazing were due to the differences in stage of maturity at time of harvest (Table 3). The forage material from the RWR pasture was baled and provided about 0.6 ton ac^{-1} (1.4 tonne ha^{-1}). A higher hay yield was expected, especially since the RWR pasture had received about 100 lb of actual N. However, the low RWR hay yield may be due to the very cool spring and poor moisture (i.e., April and May) received in 2002 (Appendix Fig. 1). Jefferson (2002) reported that spring moisture was critical for normal forage production to occur. The moisture received in June assisted in the good forage yields observed for the triticale pastures. However, hay harvesting of the S+W triticale pasture was hampered by frequent and significant rainfalls in August. Eventually, due to the precipitation received, the swathed S+W triticale forage spoiled and was discarded (Appendix Fig. 2). Nitrate-N levels in the hay and grazing forages for 2002 were not a concern as they were in 2001, due to the drought conditions. Although the mean nitrate-N level for the W triticale was above the recommended level (i.e., >0.15%), the grazing of the W triticale was not a concern since the W triticale accounted for a small portion of the entire ration that mostly consisted of S triticale.

Spring grazing performance of the cow/calf pairs on the RWR was better than on the S+W triticale pasture (Table 4). This was surprising since the nutritional qualities of the S triticale were similar if not better than the RWR (Table 5). At the tillering stage, W triticale's nutritional qualities were better than both RWR and S triticale. Cattle utilization of the RWR pasture was about 66%, while for the S+W triticale pasture it was only 38%. Although stocking rates between the two pastures were the same at 5.25 AU ac^{-1} (13 AU ha^{-1}), it was observed that the cows did not graze down the S triticale but did prefer the W triticale. The S triticale was at the boot to heading stages, thus it was felt that potential awn problems would not be a concern. Results from this study clearly showed that the cattle did not prefer grazing the Pronghorn S triticale at the boot to heading stages of maturity and this may be due to rough awn expression or other anti-nutritional factors (G. McLeod personal communication 2005). In support, Holt (1993) also reported that grazing steers avoided bearded heads of S triticale and fall rye. The study further reported that palatability was not a problem for steers grazing spring wheat or oats at the mature head stage. Iwaasa et al. (2003) reported good grazing performance of yearling steers grazing spring seeded barley and fall rye in 2001 with steer total live production per acre values similar or higher than the S+W triticale pasture.

Fall performance of steers grazing the S+W triticales either after haying or grazing provided

some interesting observations. Steer performance on the S+W triticale pasture that was previously spring grazed was much lower than for steers grazing the S+W triticale pasture that was previously hayed (Table 4). Average daily gains were almost three times higher for the steers on the S+W triticale pasture three compared to the S+W triticale pasture four. Differences in the proportion of spring vs. winter triticale available forage biomass may be a possible explanation for the observed difference in animal performances. In pasture four, S triticale accounted for about 48% of the total available forage biomass and this consisted of material that was not grazed previously and thus was very mature. In pasture three, S triticale accounted for about 14% of the total available forage biomass since much of the material was hayed. Higher forage production values for W triticale were observed in pasture three vs. four, and were 1,073 lb ac^{-1} (1,203 kg ha^{-1}) vs. 870 lb ac^{-1} (975 kg ha^{-1}), respectively (Table 3). Although these results are only based on limited data it is plausible that the increased W triticale forage production observed in pasture three was caused by the haying operation which opened up the canopy and reduced S triticale competition. Higher grazing utilizations were observed for pasture three vs. four and were 69 vs. 49%, respectively. Therefore, poor animal performance on pasture four was expected due to palatability problems with the mature S triticale and the lower amount of W triticale forage available. Results from this study showed that grazing management of annual cereals such as S+W triticale is extremely important in order to achieve any animal gains. When using S triticale Pronghorn it is important that grazing occurs before the boot stage of maturity. If this is not possible then it maybe better to hay the material than to attempt grazing since palatability concerns become an issue.

Fall grazing of the RWR by steers produced excellent animal performances (>3.5 lb d^{-1}; Table 4). However, the observed benefit of the steers on the RWR maybe a result of the poor conditions the steers may have left the S+W triticale pastures. Beacom (1969) reported that changes in gut fill, from cattle coming off a pasture at an average weight below their initial weight was likely to show greater pasture gains when placed on another pasture in which they are gaining.

Forage quality

The good moisture received in 2002 provided excellent growing conditions for the spring seeded S+W triticales and, as expected, the forage quality characteristics were good (Table 5). Higher OMD, CP and lower fibre constituents were expected for the W triticale compared to the S triticale due to their different growth stages. Generally, forage quality characteristics for S+W annuals seeded in 2002 were similar or higher than other reported studies (Holt 1993; AAFRD 1993). Percent OMD and CP values for RWR were similar to those reported by other research studies (Holt 1996). As expected, forage qualities for all forages decreased with maturity, but throughout the grazing season the forage qualities (OMD, CP, and minerals K, Mg and S) were adequate to meet nutritional needs of the yearling steers and cows and calves (NRC 1996). A calcium to phosphorus (Ca:P) ratio between 1:1 and 2:1 is recognized as desirable for optimum livestock performance. Since the Ca:P ratio in 2002 was lower than 1 for all cereal and grass treatments, a salt and mineral supplement was provided to all grazing cattle.

2003

Forage and grazing performance

The plant count in the spring of 2003 was very similar to the fall plant count in 2002 and were 86 and 89 plants per m^2, respectively. The 2003 result confirms our earlier observation

made in 2002 that the plant count value for the PC rye was much lower when compared to the 2000 PC rye plant counts.

Available forage yields (DM basis) for PC rye harvested at the flowering stage for haying was about 4,722 lb ac^{-1} (5,292 kg ha^{-1}) which was excellent forage production and showed the advantage of gaining that important spring moisture (Table 3). The forage production from the S+W triticales and RWR were only about 30% and 70% of the PC rye forage hay production, respectively. The baled forage material harvested from the PC rye, RWR and S+W triticales were 1.8, 0.6 and 0.3 ton ac^{-1}, respectively. Forage production for the S+W was higher on the pasture grazed compared to the pasture that was harvested for hay and the values were 1,498 lb ac^{-1} and 1,124 lb ac^{-1}, respectively (Table 3). The difference in forage production between the two pastures can be attributed to the time of harvest, with grazing at the beginning of July and the hay harvested at the end of July. Triticale forage production in 2003 vs. 2002 was 28% less for the grazed pasture and about 70% less for the hayed pasture. Forage production for the RWR was also considerably less in 2003 vs. 2002. The very dry and hot conditions (Appendix Fig. 1) observed at the end of June and all of July adversely affected the two triticale forage productions the longer it was allowed to stand due to reduced growth and shedding of leaves as a result of moisture stress caused by the drought (Kramer 1969). Clearly, the PC rye and RWR benefited from the early good spring moisture that the spring seeded triticales were not able to utilize. Forage production for the RWR and PC rye pastures harvested at a growth stage (i.e., tillering) best for grazing was about 1,024 lb ac^{-1} (1,432 kg ha^{-1}) and 3,527 lb ac^{-1} (3,954 kg ha^{-1}), respectively. As stated previously, the lower forage yields associated with grazing was due to the differences in stage of maturity at time of harvest (Table 3). Although it was only the first production year for PC rye, it clearly provided more forage biomass for grazing and potential hay production than either the RWR or S+W triticales. The perennial nature of the PC rye and its ability to utilize the early spring moisture was a definite advantage over using annual cereals for forage production.

The very hot and dry environmental conditions experienced in the summer of 2003 resulted in low forage regrowth values for the PC rye after the initial harvest (i.e., grazing and haying) and the values were 1,554 lb ac^{-1} (1,742 kg ha^{-1}) and 1,701 lb ac^{-1} (1,907 kg ha^{-1}), respectively. The lower forage production from the PC rye pasture that had been grazed compared to the hayed pasture was probably due to the higher animal utilization and trampling effect of the grazing animals, which resulted in less regrowth potential. Although some grazing was attempted on the PC rye pastures, the grazing only lasted for three days and then it was discontinued. Both the RWR and S+W triticale pastures had very little to no regrowth so no further grazing was attempted on these pastures.

Average daily gains for the yearling steers grazing in the spring (i.e., late May) on RWR and PC rye were 1.8 lb d^{-1} and 2.5 lb d^{-1} (Table 4). Better rates of gain on the PC rye were expected due to the higher forage quality (i.e., %OMD and %CP) (Table 5) and forage biomass available (Table 3 and 5). The S+W triticales ADG was only 1.3 lb d^{-1} even though forage quality was also very good (Table 5). The hot and dry grazing environment experienced at that time of grazing (i.e., after the first week in July) and the lower amount of S+W triticale forage that was available are possible explanations for the lower ADG observed for the triticale compared to PC rye and RWR which were grazed in May and early June. Another reason why the cattle did not gain as well on the S+W triticale pasture may be due to utilization rates. The S+W triticale pasture was utilized at a higher level than the RWR and PC rye and the values were 62.0% vs. 43.8% and 53.3%, respectively. Therefore, the cattle may have grazed the S+W triticale a few

days longer than necessary which could have affected animal weight gains. Grazing days (GD) per acre values were similar between PC rye and RWR with the lowest GD for S+W triticales (Table 4). In 2002 it was observed that cows and calves did not appear to graze the spring triticale once it started to head. However, this was not observed as much for the steers, although the steers were grazing the S+W triticale pasture for only six days. In 2002, the cows and calves had a grazing utilization on the S+W triticales of around 38%, while in 2003 the steers had a utilization of about 62%. It is unclear why the utilization rates between years are so different for the two cattle types. It is possible that the much higher forage production provided in 2002 from the S+W triticale pastures allow greater selectivity from the cows and calves compared to the limited forage production offered to the yearling steers in 2003. The S+W triticale forage production for grazing in 2002 was 2,095 lb ac^{-1} compared to 1,498 lb ac^{-1} in 2003.

Forage quality

The good spring moisture in 2003 was in contrast to the dry and hot summer of 2003 and greatly affected the forage quality of the grass and cereals harvested during those time periods (Table 5). At similar stages of plant maturity (i.e., tillering) the W triticale had the highest percent OMD and CP followed by PC rye and then RWR. Generally, the forage quality constituents in 2003 vs. 2002 for S+W triticale and RWR were similar in the spring but poorer during the summer. Throughout the grazing season the forage qualities (OMD, CP, K, Mg and S) for all treatments were adequate to meet nutritional needs of the yearling steers and cows and calves (NRC 1996). The Ca: P ratios in 2003 for the different forage treatments were closer to the 1:1 and 2:1 desired ratio.

2004

Forage and grazing performance

For the third time the PC rye did not survive through another winter period. Why the PC rye from 2003 did not survive through to 2004 maybe due to the drought conditions experienced in the summer of 2003 or a combination of the drought and grazing stress. Very little research has been conducted evaluating the grazing tolerance of PC rye. It is recommended to graze the PC rye at the early boot stage (S. Acharya personal communication 2005) which was very close to the stage it was grazed at in this study. The PC rye pasture was grazed at the end of May at a utilization rate of about 53% and then again in the middle of July at a utilization rate of only 40%. The winter period of 2003/2004 did not appear to contain any severe temperature fluctuations that might contribute to increasing the potential of winter killing the PC rye as may have been the case for the winters of 2000/2001 and 2001/2002 (Appendix Fig. 1). The plant count taken at the beginning of October for the PC rye seeded at the end of August was 72 plants per m^2. Plant count values taken in 2004 were similar to those in 2001 and 2002, which were 67 and 86 plants per m^2. It is unclear why the plant counts per m^2 for 2000 was sometime twice that of any other years. In 2000 the PC rye was seeded with a hoe drill at the end of June under excellent moisture conditions. In subsequent re-seedings the PC rye was done with a Flexicoil air seeder and later in the season (i.e., July and August). For all PC rye seedings a germination test was done and the germination values were similar. Since the last three PC rye plant counts are fairly similar and were seeded with the same drill it possible that the hoe drill used in 2000 to seed the PC rye may have been seeding at a higher rate.

Compared to other years, 2004 generally produced the highest available hay yields (DM basis) for S+W triticales and RWR and the yields were 5,774 lb ac^{-1} (6,472 kg ha^{-1}) and 2,935 lb ac^{-1} (3,290 kg ha^{-1}), respectively (Table 3). The baled forage material harvested from S+W and

RWR were 2.3 and 1.25 ton ac^{-1}, respectively. Available forage yields at time of grazing was also the highest in 2004 than for any other year for S+W triticales and RWR and the yields were 2,177 lb ac^{-1} (2,440 kg ha^{-1}) and 1,974 lb ac^{-1} (2,213 kg ha^{-1}), respectively. Excellent spring moisture that was received in May greatly facilitated the good forage production that was observed (Jefferson 2002).

Although there were some good regrowth of the S+W triticale forages in 2004 the regrowth characteristics for pasture three and four following haying or grazing was different from 2002. In 2004, for pasture three, there was not a large forage regrowth difference between the S vs. W triticales following the haying operation as was observed in 2002 (Table 3). An explanation for this maybe due to the large amount of forage that was produced by the S triticale in 2004 (62% higher forage production) vs. 2002 which could have utilized most of the available soil N just to meet the N needs of the above forage growth (80 to 90 lb of N ac^{-1} required). Therefore, after the hay harvesting the S and W triticales may not have had sufficient N fertility to perform as in 2002. For pasture four, the early summer grazing in 2004 with yearling steers was quite uniform with the S and W triticales being grazed equally as well with the pasture being utilized to about 60%. Steers in 2003 grazed the S+W triticales at a similar utilization rate and did not seem to have any grazing problem using the two triticales. Therefore, unlike in 2002 where the cows avoided grazing maturing S triticale when it went into the heading stage, it appears that the steers may have not learned or acquired this behavior yet. It was expected that cows would do a better job at grazing the pasture since they were at a higher stocking rate than the steers (5.25 AU ac^{-1} vs. 3.4 AU ac^{-1}) and might be less discriminating on the forage source. Therefore, when it comes to grazing S triticale the type of animal and at what stage the forage is at are important to consider. The regrowth of both RWR pastures in 2004 were similar regardless whether the pastures were hayed or grazed previously (Table 3). The RWR forage production in 2002 and 2004 were similar which was expected since both years provided very good moisture.

The 2004 spring grazing performance of yearling steers was best on RWR and then S+W triticales (Table 4). Grazing utilization rates for S+W triticales and RWR were 60 and 74%, respectively. The 2004 ADG and TLP values for RWR and S+W triticales were higher than any other year and this was likely a reflection of the good forage production from each of the pastures. Researchers have reported that intake and gains can be affected when forage dry matter availability is less than 1,000 pounds per acre (Hand 1996). Rayburn (1986) and Minson (1990) concluded that grazed forage intake was maximized when forage availability was equal to or greater than 2000 lb dry matter per acre. In addition, Clark and Campbell (1969) reported that livestock usually lose weight when moved from dry feed to fresh herbage and results have observed that sometimes over four weeks can elapse before the loss was regained. Therefore, the excellent steer gains that were observed on RWR and S+W triticale test pastures may have been partly a result of the initial loss in weight as the cattle were moved from dry feed into the holding pastures and then recovered some of that weight loss as they grazed the test pastures. Although the steers were on crested wheatgrass and RWR holding pastures for the month of May, they also were receiving some dry forage along with the fresh forage. Prior to the steers being placed on the RWR and S+W triticale pastures they were allowed to graze a pretest or adjustment pasture that was similar nutritionally and in sward characteristics to the test pastures for about three days. Although attempts were made to minimize the drop in weight and shorten the recovery period, it is possible that the gains observed on the test pastures by the steers maybe due to some compensatory growth (Ensminger and Olentine 1978).

Fall performances of steers grazing the RWR were better on pasture five vs. six and this may

have been due to the better regrowth and more forage being available (Table 3 and 4). During the spring grazing period, pasture five was only grazed to a utilization level of 32% and not to the 55% target level. As a result of this, the additional carryover and good growing conditions of 2004 produced a fall grazing pasture that contained more forage biomass at good quality. Even though pasture five was grazed at a utilization level of 74% this did not seem to affect the performance of the steers for reason stated earlier. Steers grazing in the fall on pasture four gained better than pasture three and this was probably due to the high forage biomass available (Table 3 and 4). However, in contrast to the results observed in 2002, pasture three in the fall following haying did not have a higher proportion of W triticale compared to pasture four after grazing. Unlike 2002 the grazing steers in 2004 did not have the same difficulty in grazing the S+W triticale mixture. The inability of the cows in 2002 to graze the S triticale in early summer only increased the grazing problem for the steers in the fall with some of the S triticale becoming very mature. Because the steers in 2004 were able to grazing the S+W triticale effectively during the summer period the regrowth and remaining S+W triticales during the fall grazing period did not result in a grazing problem or avoidance of the S triticale.

Table 3. Average forage yields and percent nitrate-nitrogen for PC rye, Russian wildrye and spring and winter triticale at different maturity stages from 2002 to 2004 (n=5).[1]

Year & Rotation	Harvest date	Species	Stage of maturity	Harvest method	Forage yield (lb/ac)	% NO3-N
2002						
3	August 13	Spring - Triticale	Heading	Hayed	3793 (3384)	0.02
3	August 13	Winter - Triticale	Tillering	Hayed	679 (606)	0.08
regrowth 3	September 13	Spring-Triticale	Ripe head	Grazing	189 (169)	0.01
regrowth 3	September 13	Winter-Triticale	Tillering	Grazing	1203 (1073)	0.00
4	July 11	Spring - Triticale	Boot	Grazing	1892 (1688)	0.06
4	July 11	Winter - Triticale	Tillering	Grazing	456 (407)	0.31
regrowth 4	September 13	Spring-Triticale	Ripe head	Grazing	891 (795)	0.02
regrowth 4	September 13	Winter-Triticale	Tillering	Grazing	975 (870)	0.07
5	July 11	RWR	Heading	Grazing	2154 (1922)	0.00
regrowth 5	September 23	RWR	Vegetative	Grazing	1472 (1313)	0.00
6	July 22	RWR	Heading	Hayed	2802 (2500)	0.02
regrowth 6	September 23	RWR	Vegetative	Grazing	2255 (2012)	0.00
2003						
1	June 12	PC-Rye	Flowering	Hayed	5292 (4722)	0.06
regrowth 1	July 21	PC-Rye	Flowering	Grazing	1907 (1701)	0.10
2	May 27	PC-Rye	Tillering	Grazing	3954 (3527)	0.11
regrowth 2	July 21	PC-Rye	Late flower	Grazing	1742 (1554)	0.06
3	July 24	Spring - Triticale	Soft dough	Hayed	1169 (1043)	0.32
3	July 24	Winter -Triticale	Tillering	Hayed	91 (81)	0.07
4	July 11	Spring - Triticale	Boot	Grazing	1433 (1278)	0.08
4	July 11	Winter -Triticale	Tillering	Grazing	247 (220)	0.37
5	May 27	RWR	Tillering	Grazing	1432 (1024)	0.00
6	June 17	RWR	Heading	Hayed	3640 (3247)	0.02
2004						
3	July 28	Spring - Triticale	Soft dough	Hayed	6155 (5491)	NA
3	July 28	Winter -Triticale	Tillering	Hayed	317 (283)	NA

Table 3. Average forage yields and percent nitrate-nitrogen for PC rye, Russian wildrye and spring and winter triticale at different maturity stages from 2002 to 2004 (n=5).

Year & pasture	Harvest date	Species	Stage of maturity	Harvest method	Forage yield kg ha^{-1} (lb ac^{-1})	% Nitrate-N
2002						
	August 13	Spring - Triticale	Heading	Haved	1791 (1584)	0.02
	August 13	Winter - Triticale	Tillering	Haved	679 (606)	0.01
regrowth	September 13	Spring-Triticale	Late head	Grazing	1591 (1691)	0.01
regrowth	September 13	Winter-Triticale	Tillering	Grazing	1203 (1073)	0.01
3	July 15	Spring - Triticale	Boot	Grazing	1892 (1685)	0.08
"	July 15	Winter - Triticale	Tillering	Grazing	456 (407)	0.11
regrowth "	September 13	Spring-Triticale	Late head	Grazing	891 (795)	0.02
regrowth "	September 13	Winter-Triticale	Tillering	Grazing	975 (870)	0.01
	July 31	RWE	Heading	Grazing	2763 (2422)	0.09
regrowth	September 2	RWE	Vegetative	Grazing	4731 (4218)	0.01
"	July 22	RWE	Heading	Haved	5603 (5000)	0.01
regrowth	September 2	RWE	Vegetative	Grazing	2241 (2012)	0.01
2003						
	June 25	PC-Rye	Flowering	Haved	5054 (4510)	0.08
regrowth	July 25	PC-Rye	Flowering	Grazing	1801 (1608)	0.01
2	May 27	PC-Rye	Heading	Grazing	4984 (4451)	0.1
regrowth 2	July 25	PC-Rye	Late flower	Grazing	2423 (2163)	0.04
	May 28	Spring - Triticale	Soft dough	Haved	1869 (1668)	0
	May 28	Winter - Triticale	Heading	Haved	0	0.07
4	July 31	Spring - Triticale	Boot	Grazing	1432 (1278)	0.06
"	July 31	Winter - Triticale	Tillering	Grazing	255 (228)	0.03
	July 29	RWE	Heading	Grazing	6 (5)	0.08
5	June	RWE	Heading	Haved	5601 (5000)	0.01
2004						
	June 29	Spring - Triticale	Soft dough	Haved	6109 (5451)	0
	July 29	Winter - Triticale	Tillering	Haved	457 (408)	0.01

regrowth 3	Aug 31	Spring - Triticale	Boot	Grazed	407 (363)	NA
regrowth 3	Aug 31	Winter -Triticale	Tillering	Grazed	634 (566)	NA
4	June 24	Spring - Triticale	Boot	Grazed	2063 (1841)	NA
4	June 24	Winter -Triticale	Tillering	Grazed	377 (336)	NA
regrowth 4	Aug 31	Spring - Triticale	Boot	Grazed	492 (439)	NA
regrowth 4	Aug 31	Winter -Triticale	Tillering	Grazed	861 (768)	NA
5	June 3	RWR	Boot	Grazed	2213 (1974)	NA
regrowth 5	Aug 31	RWR	Boot	Grazed	1585 (1414)	NA
6	June 23	RWR	Heading	Hayed	3290 (2935)	NA
regrowth 6	Aug 31	RWR	Boot	Grazed	1275 (1137)	NA

[1] PC rye pastures for 2001, 2002 and 2004 did not survive the winter.

[2] A nitrate level less than 0.15% is safe for cattle to consume.

[3] Due to the drought of 2001 no grazing of the triticale pastures occurred due to the high nitrate levels, the forage material was baled.

Five samples were randomly taken for each pasture.

NA =result not available or analyses was not required.

Table 4. Average animal performances in 2002, 2003 and 2004 on PC rye, Russian wildrye and spring and winter triticale pastures.[1&2]

Year & Treatment	Date	Average daily gain			Total gain per acre			Forage
		Steer	Cow	Calf	Steer	Cow	Calf	
2002								
3 Triticale	Sept 16	0.7 (1.5)			50.4 (45.3)			74.1 (30.0)
4 Triticale	July 12		-1.0 (-2.2)	0.8 (1.8)		130.9 (-117.0)	103.7 (92.9)	129.6 (52.5)
4 Triticale	Sept 16	-0.4 (-0.8)			-26.7 (-23.7)			74.1 (30.0)
5 RWR	July 12		2.69 (5.93)	1.21 (2.66)		244.1 (217.9)	109.8 (97.8)	90.7 (36.8)
5 RWR	Sept 24	1.8 (4.0)			101.1 (90.5)			56.2 (22.8)
6 RWR	Sept 24	1.69 (3.73)			124.1 (110.9)			73.5 (29.8)
2003								
1 PC-Rye	July 22	0.7 (1.6)			22.9 (20.5)			31.48 (12.8)
2 PC-Rye	May 28	1.2 (2.5)			133.0 (119.0)			132.7 (53.8)
2 PC-Rye	July 22	-0.3 (-0.7)			-9.4 (-8.5)			31.5 (12.8)
4 Triticale	July 12	0.6 (1.3)			36.5 (32.4)			63.0 (25.5)
5 RWR	May 28	0.8 (1.8)			115.3 (103.0)			138.9 (56.2)
2004								
3 Triticale	Sept 01	0.85 (1.88)			37.77 (33.84)			44.44 (18)
4 Triticale	June 25	1.48 (3.26)			164.44 (146.7)			111.11 (45)
4 Triticale	Sept 01	1.07 (2.35)			83.22 (74.02)			77.78 (31.5)
5 RWR	June 11	1.71 (3.76)			281 (250)			164.20 (66.5)

Table 4. Average animal performances in 2002, 2003 and 2004 on PC rye, Russian wildrye and spring and winter triticale pastures.[A]

Year & pasture	Date	Average daily gain kg d^{-1} (lb d^{-1})			Total live weight production kg ha^{-1} (lb ac^{-1})			Grazing d ha^{-1} (d ac^{-1})
		Steer	Cow	Calf	Steer	Cow	Calf	
2002								
1 Triticale	Sept 10	0.7 (1.5)			503 (447)			74 (30)
4 Triticale	July 12		0.9 (2.2)	0.5 (1.2)		1,000 (1,117)	301 (269)	129 (52)
4 Triticale	Sept 10	0.4 (0.8)			267 (238)			74 (30)
5 RWE	July 12		2.69 (5.93)	1.25 (2.66)		542 (257)	169 (150)	99 (40)
5 RWE	Sept 24	1.8 (4.0)			161 (143)			99 (40)
6 RWE	Sept 24	1.09 (2.53)			124 (110)			74 (30)
2003								
1 PC-Rye	July 22	0.7 (1.6)			224 (200)			74 (30)
2 PC-Rye	May 29	2.2 (4.9)			1,000 (1,000)			74 (30)
2 PC-Rye	July 22	0.5 (1.0)			99 (88)			74 (30)
4 Triticale	July 12	0.9 (1.9)			267 (238)			129 (52)
5 RWE	May 29	1.8 (4.0)			1,000 (1,000)			129 (52)
2004								
1 Triticale	Sept 01	0.85 (1.88)			1,000 (892)			99 (40)
4 Triticale	June 25	1.4 (3.2)			1,000 (892)			74 (30)
4 Triticale	Sept 01	0.67 (1.5)			1,000 (892)			99 (40)
5 RWE	June 11	3.7 (8.2)			250 (223)			166 (67)

7 RWR	Sept 07	3.47 (3.25)			32.1 55 (101.74)				(31.5)
9 RWR	Sept 07	3.08 (2.38)			84.00 (74.07)				(31.5)

NA = results not available.
Total live weight production = average daily gain x grazing days (Schellenberg et al. (2009)).
[illegible] rye pasture for 2001, 2002 and 2004 did not survive the winter.

Table 5. Average forage qualities in 2002, 2003 and 2004 for PC rye, Russian wildrye and spring and winter triticale.

Pasture number and forage type	Harvest date	Harvested plant stage	OM %	OMD %	ADF %	NDF %	CP %	P %	Ca %
2002									
3 Triticale-spring	Aug 13	Heading	92.5	49.0	30.8	57.7	8.4	0.2	0.2
3 Triticale-winter	Aug 13	Tillering	82.6	70.0	21.8	37.1	20.7	0.33	0.2
1 Triticale-spring	Sept 13	Ripe head	NA	NA	50.0	74.2	4.2	0.25	0.2
1 Triticale-winter	Sept 13	Tillering	87.6	75.0	20.0	40.7	21.3	0.41	0.1
4 Triticale-spring	July 31	Boot	93.2	66.7	29.2	50.7	10.2	0.27	0.2
4 Triticale-winter	July 31	Tillering	85.2	76.0	19.6	34.2	25.6	0.41	0.4
2 Triticale-spring	Sept 13	Ripe head	90.4	46.5	57.2	80.7	4.2	0.25	0.2
2 Triticale-Winter	Sept 13	Tillering	87.2	77.0	19.2	37.1	20.2	0.4	0.2
7 RWR	July 31	Heading	89.0	59.7	35.0	58.2	13.5	0.29	0.2
7 RWR	Sept 25	Vegetative	86.7	80.5	27.1	49.2	24.1	0.4	0.2
9 RWR	July 22	Heading	90.7	67.2	29.7	49.7	15.4	0.24	0.2
9 RWR	Sept 25	Vegetative	89.4	80.0	26.2	48.2	17.4	0.29	0.2
2003									
9 –Rye	June 12	Flowering	91.24	61.24	36.2	51.04	10.4	0.28	0.2
7 –Rye	June 23	Flowering	91.50	61.54	37.00	53.47	10.1	0.25	0.2
2 –Rye	May 27	Tillering	92.40	69.00	24.05	40.23	20.80	0.38	0.2
6 –Rye	June 23	Flowering	91.10	61.24	39.85	55.81	10.43	0.25	0.2
Triticale-spring	June 24	Soft dough	94.17	64.80	29.4	50.50	8.32	0.25	0.2
Triticale-winter	June 24	Tillering	NA	NA	19.20	40.2	20.40	0.39	0.4
4 Triticale-spring	June 23	Boot	91.07	70.71	37.80	60.04	10.71	0.26	0.2
4 Triticale-winter	June	Tillering	86.07	77.00	24.47	45.08	25.50	0.42	0.4
2 Rye	May 27	Tillering	91.47	71.4	29.2	47.2	24.30	0.37	0.2

5 RWR	Sept 01	1.47 (3.23)			113.55 (101.74)			77.78 (31.5)	
6 RWR	Sept 01	1.08 (2.38)			84.00 (74.97)			77.78	(31.5)

NA = results not available.

[1]Total live weight production = average daily gain x grazing days. (Schellenberg et al. (1999)).

[2]PC rye pastures for 2001, 2002 and 2004 did not survive the winter.

Table 5. Average forage qualities in 2002, 2003 and 2004 for PC rye, Russian wildrye and spring and winter triticale.[1]

2002									
3 Triticale spring	Aug 13	Heading	93.3	49.9	30.8	53.7	8.4	0.2	0.2
3 Triticale winter	Aug 13	Tillering	82.6	70.1	21.0	37.1	20.7	0.38	0.2
3 Triticale spring	Sept 13	Ripe head	NA	NA	30.0	53.4	11	0.28	0.2
3 Triticale winter	Sept 13	Tillering	87.6	73.9	20.9	40.1	21.3	0.41	0.3
4 Triticale spring	July 11	Boot	91.3	65.7	28.1	50.7	19.2	0.37	0.3
4 Triticale winter	July 11	Tillering	85.2	76.0	19.5	34	28.6	0.41	0.4
4 Triticale spring	Sept 13	Ripe head	89.4	46.8	37.3	60.1	9.2	0.23	0.2
4 Triticale winter	Sept 13	Tillering	87.2	77.0	19.3	37.1	26.7	0.43	0.3
5 RWR	July 11	Heading	88.9	55.7	28.0	53.2	15.7	0.29	0.2
5 RWR	Sept 23	Vegetative	89.1	60.5	27.3	49.4	14.3	0.33	0.2
6 RWR	July 22	Heading	88.7	57.5	28.7	53.7	13.4	0.24	0.2
6 RWR	Sept 23	Vegetative	89.4	60.9	26.2	48.3	13.9	0.26	0.2
2003									
1 PC-Rye	June 12	Flowering	93.24	60.24	30.51	51.94	16.04	0.28	0.26
1 PC-Rye	July 21	Flowering	91.88	61.84	27.96	51.47	18.13	0.25	0.26
2 PC-Rye	May 27	Tillering	91.80	68.65	24.95	46.35	20.80	0.38	0.25
2 PC-Rye	July 21	LFlowering	93.03	54.34	29.85	55.11	14.43	0.21	0.20
3 Triticale spring	July 24	Soft dough	94.05	54.86	29.41	56.36	13.13	0.25	0.18
3 Triticale winter	July 24	Tillering	NA	NA	19.28	40.35	26.48	0.29	0.48
4 Triticale spring	July 11	Boot	91.07	70.71	17.89	36.04	19.33	0.28	0.30
4 Triticale winter	July 11	Tillering	84.97	77.69	24.47	45.08	28.78	0.28	0.51
5 RWR	May 27	Tillering	91.47	57.45	29.47	57.25	14.30	0.32	0.31

6 RWR	June 17	Heading	93.73	56.36	31.72	58.73	14.35	0.25	0.27
2004									
3 Triticale spring	July 28	Soft dough	93.13	55.46	31.83	55.98	10.18	0.18	NA
3 Triticale winter	July 28	Tillering	86.84	73.95	22.15	41.45	22.88	0.39	NA
3 Triticale spring	Aug 31	Boot	91.35	72.20	25.23	50.21	20.39	0.43	NA
3 Triticale winter	Aug 31	Tillering	88.81	73.41	22.38	44.05	23.10	0.45	NA
4 Triticale spring	June 24	Boot	89.78	78.48	22.16	41.22	20.55	0.43	NA
4 Triticale winter	June 24	Tillering	86.84	80.06	16.05	29.30	26.29	0.38	NA
4 Triticale spring	Aug 31	Boot	93.04	67.54	26.94	53.51	18.59	0.38	NA
4 Triticale winter	Aug 31	Tillering	88.95	74.55	21.22	42.77	24.74	0.40	NA
5 RWR	June 3	Boot	92.05	61.53	27.78	56.26	15.45	0.24	NA
5 RWR	Aug 31	Boot	90.94	59.85	28.68	56.79	16.34	0.27	NA
6 RWR	June 23	Heading	91.50	61.99	27.65	53.74	15.79	0.31	NA
6 RWR	Aug 31	Boot	90.27	60.22	28.34	56.33	16.01	0.27	NA

[1]Organic matter (OM), organic matter digestibility (OMD), acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), phosphorus (P), calcium (Ca), Russian Wildrye grass (RWR) and late flowering stage (LFlowering)
NA = results not available.

Forage quality

At similar stages of plant maturity (i.e., boot etc) the S+W triticales had better forage qualities than RWR in the early summer and fall grazing period (Table 5). Throughout the grazing season the forage qualities for all cereal and grass treatments were adequate to meet nutritional needs of the yearling steers and cows and calves (NRC 1996). Similar to 2002, the 2004 P levels were higher in the cereal forages and therefore a good salt and mineral supplement should be provided for grazing animals.

Over all years

When comparing the average available hay and grazing yields over the three years (2002 to 2004) for S+W triticales and RWR there were no significant differences (P>0.30). This was not surprising due to the large variation over years due to the environmental conditions (e.g., drought etc.) and small degrees of freedom available. As expected the average grazing forage yields for RWR and S+W triticales were numerically smaller than hay yields and the values were 2,634 lb ac^{-1} (2,952 kg ha^{-1}) and 2,882 lb ac^{-1} (3,229 kg ha^{-1}), respectively for the grazing and 2,895 lb ac^{-1} (3,244 kg ha^{-1}) and 3,630 lb ac^{-1} (4,068 kg ha^{-1}), respectively for the haying. Although not significant, the S+W triticales consistently gave higher average forage biomass yields over RWR by as much as 11% for grazing and 25% for haying. However, the added cost of re-seeding an annual cereal crop each year for the potential forage increase may not have much economical benefit. Unfortunately, we only had one year of forage data for PC rye (2003) in which very high

available hay and grazing forage yields were observed and the values were 4,722 lb ac^{-1} (5,292 kg ha^{-1}) and 5,083 lb ac^{-1} (5,696 kg ha^{-1}), respectively (Table 3). PC rye is reported to last over three to four growing seasons (Meristem Information Resources Ltd. 2004) and small plot studies conducted at AAFC-SPARC have also found that PC rye lasted between three to four years but with forage production declining each year. It has been reported that in a two cropping system that PC rye forage production declines by 20% within the first three years, with a further 30% decline during the fourth year (S. Acharya personal communication 2005). Although PC rye could be a very promising forage resource for southwest Saskatchewan, especially for spring and fall grazing, the key to its successful use is dependent upon its longevity to produce for three to four growing seasons.

Average total live weight grazing production (TLP) for RWR over the three years was numerically ($P = 0.08$) higher than S+W triticales and the values were 182 lb ac^{-1} (204 kg ha^{-1}) vs. 99 lb ac^{-1} (111 kg ha^{-1}). However, the grazing for RWR occurs in the spring and fall period, while for S+W triticales the grazing occurred in the summer and fall. The very hot and dry drought period of 2003 greatly reduced the grazing potential on S+W triticales and the TLP in 2003 on S+W triticales was 1/3 that of the RWR. In addition, palatability problems with the S triticale also reduced TLP in 2002. Average grazing days per acre did not differ ($P>0.30$) between RWR and S+W triticales over the three years and the values were 58 d ac^{-1} (146 d ha^{-1}) and 44 d ac^{-1} (109 d ha^{-1}), respectively. Although there was more forage biomass for the S+W triticales for the animal to graze the palatability and poor animal performance due to the summer drought of 2003 required the animals to be taken out of the pasture sooner than desired. PC rye's TLP (119 lb ac^{-1} or 133 kg ha^{-1}) and grazing days per acre (54 d ac^{-1} or 133 d ha^{-1}) values were similar to RWR and S+W triticale but were only based on one year's of data.

Small plot study

Plant survival

When averaged across all seeding dates, Prego triticale had the lowest plant survival of all cultivars ranging from a low of 0.3 ± 4.7 % with July 18 seeding to a high of 96.9 ± 1.9% for September 7 seeding (Table 6). The low survival of Prego is likely due to its European origin, where low-temperature tolerance is not as critical to winter survival as on the Canadian prairies. In contrast, Prima fall rye had the greatest plant survival when averaged across all seeding dates; ranging from a low of 93 ± 4.4 % for August 30 to a high of 100% for seeding on August 3 and 16, as well as September 7.

Of the three winter triticale cultivars, Pika had the greatest survival when averaged across all seeding dates, Bobcat was intermediate, and Prego had the lowest plant survival as previously mentioned (Table 6). Plant survival was observed to be greatest for the winter triticale cultivars and CDC Clair winter wheat when planted on September 7, and generally lowest for July 18 seeding (Table 6).

When compared to the winter cereals for plant survival under field conditions, PC rye was tied for second greatest for a mid-July seeding date, and tied for the best survival for early-and-mid August seeding dates ($P<0.05$) (Table 6). Plant survival of PC rye was not significantly different ($P>0.05$) from the other cultivars within the August 30 and September 7 and 17 seeding dates.

Averaged across all cultivars within seeding dates, defoliation significantly reduced plant

Table 6. Least square means (SE) for plant survival in 2002 of winter triticale (Bobcat, Pika and Prego), Clair winter wheat, Prima fall rye and PC rye, seeded at Swift Current, SK at six different dates in 2001; plants were either defoliated (D) or non-defoliated (ND).

		Cultivars						
Seeding date	Defoliation	Bobcat	Pica	Prego	Clair	Prima rye	PC rye	Mean
July 18		*Plant Survival (%)*						
	D	34.7a[x] (5.6)[y]	48.0a	0.3a	36.7a	95.3a	30.0a	40.8A (2.3)[y]
	ND	25.3a	58.7a	0.3a	37.9a	96.0a	78.2b	49.4B
	Mean	30.0B[z](4.7)[y]	53.4C	0.3A	37.3B	95.7D	54.1C	
August 3								
	D	52.0 (7.7)[y]	74.0	18.7	64.7	100.0	82.7	65.4 (3.1)[y]
	Mean	49.0B[z] (6.4)[y]	71.0C	21.4A	70.0C	100.0D88.4D		
August 16								
	D	73.3 (5.8)[y]	98.7	53.3	92.0	100.0	100.0	86.2A (2.4)[y]
	ND	90.7	99.3	74.7	88.0	100.0	100.0	92.1B
	Mean	82.0B[z] (4.8)[y]	99.0C	64.0A	90.0BC	100.0C 100.0C		
August 30								
	D	76.0 (6.0)[y]	94.0	64.7	80.7	92.7	80.7	81.5A (2.4)[y]
	ND	94.7	94.0	86.0	90.7	93.3	98.7	92.9B
	Mean	85.3 (4.4)[y]	94.0	75.3	85.7	93.0	89.7	
Sept. 7								
	D	90.7 (2.4)[y]	99.3	95.3	94.0	100.0	92.7	95.3A (1.0)[y]
	ND	100.0	100.0	98.6	97.3	100.0	98.7	99.1B
	Mean	95.3 (1.9)[y]	99.7	96.9	95.7	100.0	95.7	
Sept. 17								
	D	80.7 (3.8)[y]	88.0	78.0	84.7	93.3	89.3	85.7A (1.5)[y]
	ND	94.7	96.0	92.7	94.7	96.7	96.7	95.2B
	Mean	87.7 (3.1)[y]	92.0	85.3	89.7	95.0	93.0	

z = Means in the same column within a seeding date with different lower case letters are significantly different according to a LSD test (P<0.05)

y = pooled SE in parentheses

x = Means in the same row or column with different upper case letters are significantly different according to a LSD test (P<0.05).

survival ($P<0.05$) for all seeding dates except August 3, which showed only a trend for reduced survival under defoliation (Table 6). The lower winter survival for the defoliated plants may be a result of the overall lower soil temperatures experienced by these plants. Defoliation reduced the amount of standing plant material, causing increased exposure of the soil to the environmental elements, particularly soil surface cooling. For PC rye, defoliation significantly changed plant survival ($P<0.05$) only on the July 18 seeding date, reducing survival from 78.2 ± 5.6 % to 30.0 ± 5.6 % for non-defoliated and defoliated plants, respectively.

When looking at differences in plant survival for the six cultivars by seeding date (Table 6), there were no differences among forage cultivars for the August 30 to September 17 dates. In contrast, there were differences evident for the August 16 seeding date ($P<0.05$), and in moving from August 16 to earlier seeding dates, even greater reductions in survival became evident. Plant survival of PC rye was similar to Prima fall rye (100% ± 4.8 %) for August 16 seeding date, but was lower than fall rye ($P<0.05$) when seeded on July 18 (54.1 ± 4.7 % and 95.7 ± 4.7 % for PC and fall rye, respectively). Based on this information, planting PC rye in mid-August or later should ensure maximum winter hardiness, while planting in mid-July may significantly lower hardiness. Baron et al. (1999) indicated the cold tolerance of winter wheat was reduced if plants were too large prior to winter dormancy, as the incidence of disease was greater in larger plants. The reduced survival of early-seeded PC rye may be partially related to disease as well, and is an area that requires further research. In a study conducted at Lacombe, AB, Jedel and Salmon (1994) investigated three dates of fall seeding (late-August, early September, and late September) at two seeding rates using fall rye, winter wheat and winter triticale. Survival was found to be greatest in all years when planting occurred in late-August and early September, regardless of species. Notably, results of that study were in agreement with our research at Swift Current, Saskatchewan.

Results from the small plot study on PC rye are supported by the large pasture research observations. Although the seeding of the PC rye on the large pastures followed the recommendation of the breeder and developer of the PC rye cultivar, no success over the winter establishment of the PC rye occurred in 2001 and 2002. PC rye was seeded on June 28 in 2000 and re-seeded on July 18 in 2001. Both seeding dates are earlier than mid-August and thus may have had less winter hardiness.

Economic Assessment

The net margins for the six pasture systems differed widely among years and depended greatly on whether the pastures were used only for grazing by livestock, or were hayed and then grazed (Tables 7 and 8). This variability in economic performance largely reflects the growing conditions that prevailed during the study period (Appendix Figure 1). The net margins for most pasture systems tended to be highest in 2004, intermediate in 2002, and lowest in 2003. With one exception (i.e., the triticale pasture systems under the low hay price assumption), changes in the market price for livestock and hay, although impacting the absolute net margin values, had little affect on the relative rankings of the pasture treatments. In the 2002 study year, the most profitable treatment was RWR which was grazed by steers and cow-calf units ($431 ha^{-1} at high beef prices and $312 ha^{-1} at low beef prices). The net margin for the RWR pasture system which was hayed and then grazed by steers ranked second highest (29-55% lower than for the most profitable system, depending upon the price assumptions); this was followed by the triticale

systems (53-77% lower). In the 2003 study year, the most profitable pasture system was PC rye-hayed/grazed, followed by RWR-grazed and PC rye-grazed (11-67% lower). Both triticale pasture systems produced economic losses in 2003 due to the dry and hot conditions experienced in June and July. In 2004, the net margins were again highest for the RWR-grazed system ($713 ha^{-1} and $626 ha^{-1} at high and low beef prices, respectively), followed by triticale-grazed (42% lower than the best system). The triticale-hayed/grazed system ranked third highest in net earnings in 2004 (60-81% lower), while the RWR-hayed/grazed system ranked lowest.

Table 7. Annual net margins ($ ha^{-1}) for grazed and hayed/grazed pasture systems under high hay price assumptions at Swift Current (2002-2004)

Pasture Treatment	2002	2003	2004
High Steer and Calf Prices			
PC rye – grazed	-	100.52	-
PC rye- hayed/grazed	-	228.47	-
Triticale – grazed	155.75	-75.29	412.23
Triticale – hayed/grazed	199.92	-104.70	259.28
RWR – grazed	431.21	106.78	712.98
RWR – hayed/grazed	248.56	37.65	176.47
Mean	258.86	48.91	390.24
Low Steer and Calf Prices			
PC rye – grazed	-	73.33	-
PC rye- hayed/grazed	-	223.43	-
Triticale – grazed	70.37	-83.32	357.74
Triticale – hayed/grazed	188.83	-104.70	250.97
RWR – grazed	312.35	81.41	626.18
RWR – hayed/grazed	221.26	37.65	157.99
Mean	198.20	37.97	348.22

Table 8. Annual net margins ($ ha^{-1}) for grazed and hayed/grazed pasture systems under low hay price assumptions at Swift Current (2002-2004)

Pasture Treatment	2002	2003	2004
High Steer and Calf Prices			
PC rye – grazed	-	100.52	-
PC rye- hayed/grazed	-	112.77	-
Triticale – grazed	155.75	-75.29	412.23
Triticale – hayed/grazed	112.71	-129.27	133.08
RWR – grazed	431.21	106.78	712.98
RWR – hayed/grazed	193.92	-33.33	112.32
Mean	223.40	13.70	342.65
Low Steer and Calf Prices			
PC rye – grazed	-	73.33	-

PC rye- hayed/grazed	-	107.74	-
Triticale – grazed	70.37	-83.32	357.74
Triticale – hayed/grazed	101.63	-129.27	124.77
RWR – grazed	312.35	81.41	626.18
RWR – hayed/grazed	166.62	-33.33	93.84
Mean	162.74	2.76	300.63

Results of the simulated performance of the PC rye pasture systems compared with the 2002-2004 mean performance of the RWR and triticale systems are shown in Table 9. Overall, the most profitable treatment was RWR-grazed ($417 ha^{-1} at high beef prices and $340 ha^{-1} at low beef prices). When the price for hay was high, the PC rye-hayed/grazed system ranked second highest (about 55% less than the best system) at both high and low beef prices; but, at the high beef price level, triticale-grazed and RWR-hayed/grazed were also members of the group of second highest ranking pasture systems. At low hay prices, the triticale-grazed system ranked second highest (about 63% less than the best system). The economic performance of the PC-rye-grazed and triticale-hayed/grazed pasture systems generally ranked lowest under all price scenarios.

Table 9. Average and simulated performance ($ ha^{-1}) of grazed and hayed/grazed pasture systems at Swift Current.

Pasture Treatment	High Hay Price		Low Hay Price	
	High Livestock Prices	Low Livestock Prices	High Livestock Prices	Low Livestock Prices
PC rye – grazed	72.90	51.15	72.90	51.15
PC rye- hayed/grazed	169.61	165.58	77.05	73.02
Triticale –grazed	164.23	114.93	164.23	114.93
Triticale -hayed/grazed	118.17	111.70	38.84	32.38
RWR –grazed	416.99	339.98	416.99	339.98
RWR -hayed/grazed	154.23	138.97	90.97	75.71
Mean	182.69	153.72	143.50	114.53

Conclusions

Results from this study have clearly shown that the ability for PC rye to establish on dry land conditions and survive over winter in the southwest is questionable. The ability of PC rye's winter survival is very much dependent upon its seeding date. The small plot study found that planting PC rye in mid-August or later may ensure maximum winter hardiness, while planting in mid-July may significantly lower winter hardiness. When seeded in August, PC rye's plant survival rate was equal to fall rye which is noted for its winter hardiness. In agreement, the large pasture study was only successful in establishing the PC rye and surviving the winter when it was seeded in August of 2002. Previous seeding dates in June (2000) and July (2001) resulted in none of the PC rye plant surviving the winter. It is unclear whether the poor winter survival of PC rye was due to low winter hardiness, diseases or weather extremes. Why the PC rye from 2003 did not survive through to 2004 may be due to the drought conditions experienced in the summer of 2003 or a combination of the drought and grazing stress. Very little research has been

conducted evaluating the grazing tolerance of PC rye. Although it is recommended to graze the PC rye at the early boot stage, results from this study has found that grazing pressure and environmental stresses when combined during the summer can greatly affect PC rye's plant survival. In support, the small plot study also observed that PC rye's plant survival can be significantly reduced when PC rye is seeded in July and defoliated in the fall. PC rye can provide excellent hay and grazing biomass with good forage quality that can result in good animal performances. However, the key to PC rye's success is very much dependent upon its ability to stay in production for three to four years which may not be the case in southwest Saskatchewan.

For the study, both S+W triticale and RWR pastures generally produced good forage biomass of good forage quality that resulted in good animal performance. However, the results of 2002 and 2004 showed that grazing management of annual cereals such as S+W triticale is extremely important in order to achieve desired animal gains. When using S triticale it is important that grazing occurs before or at the boot stage of maturity; if this is not possible then it may be better to hay the material than to attempt grazing since palatability concerns may be an issue. However, better animal performances might be achieved by utilizing yearling cattle to graze S+W triticale at the boot stage compared to using mature cow/calf pairs. The increased grazing management that is required to effectively utilize the S+W triticale pasture and reduce palatability concerns may be more trouble than a producer is willing to deal with, especially if the producer wishes more flexibility in his decision making choices. Another major drawback to the use of spring seeded annuals for forage production in southwest Saskatchewan is potential moisture limitation. Unlike perennial forages that can utilize early spring moisture to get some production the spring seeded annual is much more sensitive to moisture deficiencies and poorer production as a result of limited spring and summer moisture conditions. As well, the added cost each year of re-seeding makes this type of forage operation more costly. Although the establishment of a perennial forage can also be costly, this cost can be amortized over a number of years. In the case of RWR, more than ten years of modest forage production (500 to 600 lb ac^{-1}) can occur or with fertilization and favourable environments, higher forage production can be achieved. The potential increase in forage production, grazing capacity, improved forage quality and reduced production variability may have additional monetary value to the producer's operation to offset the cost of the fertilizer and application.

Although the results of the economic analysis is considered preliminary, the overall general ranking of the pasture systems was RWR-grazed > triticale-grazed = PC rye-hayed/grazed > RWR-hayed/grazed > triticale-hayed/grazed = PC rye-grazed. Thus, the evidence does not provide strong support for the use of PC rye as an alternative pasture source to annual cereal or perennial grass production systems in southwestern Saskatchewan under the conditions experienced over the 2001-2004 time period. In addition, with the inability of PC rye to consistently provide three to four years of production and the uncertainty on its ability to handle grazing stresses, there is the need for further evaluation and research before this forage crop can be recommended for use in southwest Saskatchewan in place of other forage sources.

Information presented as a result of this research study and the support by SAFRR and Saskatchewan ADF acknowledged

Workshops and conferences

Invited presentation at the Western Canadian Forage and Grazing Conference (December 3-5,

2003) in Red Deer, Alberta. Information supplied to the Southwest Forage Association General Meeting (February 18, 2004 and March 4, 2005) and SAFRR Forage Review in Kindersley, Saskatchewan (March 4, 2004).

Reports
Annual and final ADF progress reports for "Extending the grazing season through the use of spring and winter seeded triticales or perennial rye cereals for pastures" in 2001, 2002, 2003 and 2004.

Tours
- Two tours (July 2003) were organized in which a total of 45 participants viewed and asked questions concerning the role that PC rye and other annual cereals can be used as a forage resource. On the research tours various information articles on the preliminary results (reports) of this study were delivered.
- Research field day (August 2004) was organized in which a total of 90 participants viewed and asked questions concerning the establishment and success of PC rye compared to other forage and cereal crops. On the research tour various information articles on the preliminary results (reports) of this study were delivered.

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Appendix

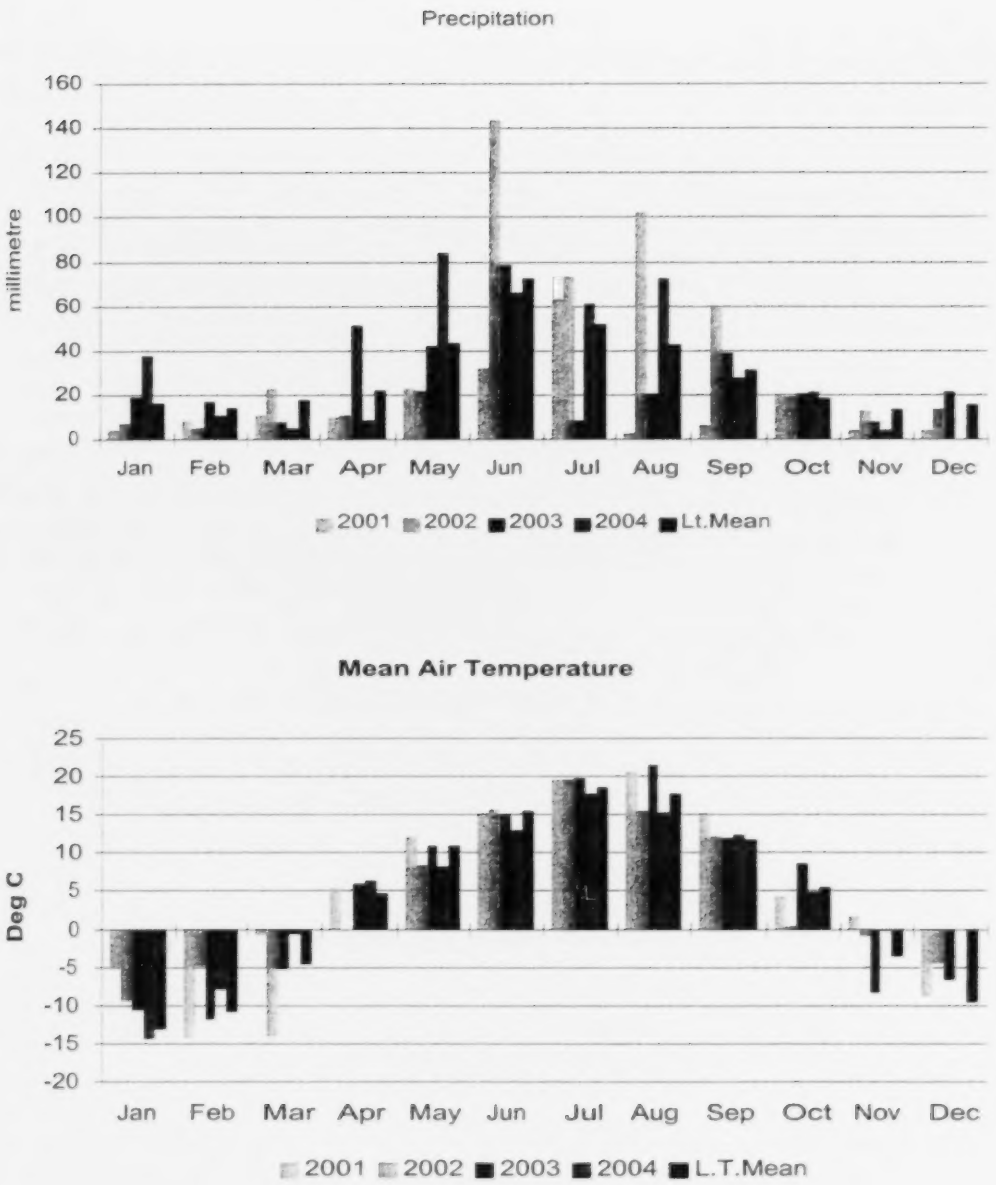

Figure 1. 2001 to 2004 precipitation and mean air temperature.